

The growth of net domestic product in Germany, 1850-1913

Holtfrerich, Carl-Ludwig

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The Growth of Net Domestic Product in Germany 1850–1913*

I.

In 1965, Walther G. Hoffmann published his path-breaking collection of time series on the growth of the German economy since 1850.¹ Subsequently, the data have been used by economists to test empirically theories of economic growth² and by economic historians as a quantitative framework for describing more exactly the process of industrialization in Germany.³ Hoffmann's figures on aggregate output, its components and factor inputs thus served as a basis for evaluation of different models of economic growth and of traditional interpretations of Germany's industrialization process, especially for the period 1850–1913. The data themselves, however, their sources, their compilation and their use in estimation procedures have not yet been subjected to a comprehensive critical analysis. This may have to do with the immense effort, which went into collecting and processing the data, especially so for the period before the First World War. At that time national income accounting had not yet been developed and therefore statistical offices failed to collect data with a view to that concept. It probably exceeds the working capacity of an individual scholar to undertake a thorough close examination of Hoffmann's numerous time series, especially for the period 1850–1913, for which most aggregate data were produced by estimation procedures selected by Hoffmann.

My contribution here has a more narrow focus and does not present the results of a new investigation into the sources. Its limited aim is, first, to take a critical look at

* I would like to thank my Frankfurt colleague, Prof. Heinz Grohmann, for a critical discussion of statistical-methodological questions.

1. Hoffmann, Walther G. et al., *Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts*, Berlin 1965.
2. E.g. Gahlen, Bernhard, *Die Überprüfung produktionstheoretischer Hypothesen für Deutschland 1850–1913. Eine kritische Untersuchung*, Tübingen 1968.
Gahlen, Bernhard, *Der Informationsgehalt der neoklassischen Wachstumstheorie für die Wirtschaftspolitik*, Tübingen 1972.
3. E.g. André, Doris, *Indikatoren des technischen Fortschritts. Eine Analyse der Wirtschaftsentwicklung in Deutschland von 1850 bis 1913*, Göttingen 1971.
Schremmer, Eckart, *Wie groß war der "technische Fortschritt" während der Industriellen Revolution in Deutschland, 1850–1913*, in: Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte, 60 (1973), pp. 433–458. Aubin, Hermann and Zorn, Wolfgang (eds.), *Handbuch der deutschen Wirtschafts- und Sozialgeschichte*, vol. 2: *Das 19. und 20. Jahrhundert*, Stuttgart 1976, especially the articles by Knut Borchardt.

the estimation procedure, by which Hoffmann aggregated his time series on the growth of Germany's real net domestic product at factor cost from data series on production of different branches of the economy, and, secondly, to recalculate the growth of the German net domestic product from 1850 to 1913 using an improved method. The difference between Hoffmann's and my results will then give an idea of the magnitude in which growth rates of Germany's net domestic product are determined by the aggregation procedure, i.e. by the assumptions underlying each method.

II.

Hoffmann presents data on the development of Germany's national product using the three standard approaches provided by national accounting: the output approach, the income approach, and the expenditure approach.⁴ The result of the income approach is a time series on net national income in *current* prices; this does not allow an assessment of economic growth in *real* terms. In contrast to this, using the expenditure and the output approaches⁵ Hoffmann computed time-series on the development of real net national product and real net domestic product. The results of the output approach are the preferred data on which to base a quantitative assessment of economic growth, because they are derived from observations of production activity in the different branches of the economy which are then aggregated into an index of production for the economy as a whole. Hoffmann's Table 101 presents the index thus constructed for the development of the German economy's real net domestic product at factor cost.⁶ This index is usually the basis for the quantification of Germany's economic growth since 1850.

In detail, the index is constructed in the following manner: The total economy is grouped into nine branches: 1. agriculture, forestry and fisheries; 2. mining and salt works; 3. industry and crafts; 4. transport; 5. commerce, banking, insurance and catering trade; 6. domestic service; 7. other services without military services; 8. military services; 9. non-agricultural housing. For each branch Hoffmann has compiled data on production of the main goods and services. The time series thus produced are valued at 1913 prices and transformed into indices of production (1913 = 100). Where necessary, these indices were then aggregated into indices of production for the above mentioned nine branches of the economy. Normally the 1913 value-added share of each product or product group was used as a weight in the aggregation procedure; a product's share in employment in later and earlier years was also sometimes used to adjust these weights. The indices of production in each branch of the economy are thus principally based on price and value-added structures in 1913⁷ which are partly themselves estimates from data found for the interwar years. Where weights were adjusted using employment shares in different years this

4. Hoffmann, *Wachstum*, pp. 165-170. See also: Stobbe, Alfred, *Volkswirtschaftliches Rechnungswesen*, 5th Ed., Berlin 1980, esp. pp. 146-151.

5. Hoffmann, *Wachstum*, pp. 451-455, 827-828.

6. Hoffmann, *Wachstum*, p. 451-452.

7. Hoffmann, *Wachstum*, p. 7.

was done on the assumption that "the structure of net production value per person employed ..., as [first] computed for 1936, can be assumed to be constant during the whole period from 1850 to 1959".⁸

The requirement to hold prices and values constant in order to obtain an index of production⁹ makes it understandable that Hoffmann assumed constant price and value-added structures. It must be criticized, however, that constant weights are used over so long a period which by definition of the industrialization process is characterized by great changes in the structure of production and prices. Therefore, Hoffmann's index is bound to produce a bias in the estimate of economic growth which must be expected to be higher the greater the distance between the year, for which production is estimated and the year (mostly 1913), from which the weights are taken.

The above criticism also applies to the index which Hoffmann constructed for Germany's real net domestic product a factor cost, which was calculated on the basis of the indices of the nine different branches of the economy. He used data from the interwar years to estimate the share of value-added of each of the nine branches and applied these as constant weights in aggregating the sector indices to an index of the whole economy's value-added in constant prices (1913).¹⁰ This procedure has two weaknesses. 1. Are the production indices of each branch also representative for the development of value-added in each branch? Hoffmann was able to produce an index of value-added, i.e. production minus intermediate goods, depreciation, inventory changes, indirect taxes,¹¹ only for the primary sector. 2. The above criticism of Hoffmann's calculation method for the branch indices also applies to his use of constant weights in computing the aggregate index. This is the point of departure for my following attempt to confront Hoffmann's procedure with a different method of aggregating the branch indices for the period 1850-1913 which takes into account changes in the economy's value-added structure and uses weights currently adjusted to the actual value-added shares in each year. This new procedure, of course, does not solve the problem connected with Hoffmann's use of constant weights to produce the branch indices themselves.

III.

In connection with the income approach to national product, Hoffmann's book contains time series on the development of the value-added (labor and capital income) of different branches. From these data I have calculated the share of each of the nine branches of the economy in total value-added in current prices. Table 1 presents the amount of value-added in current prices in each branch. In order to weaken the effect Hoffmann's choice of the base year (1913 = 100) has on the index of growth in the aggregation procedure, I have calculated annual growth factors $\frac{I_t}{I_{t-1}}$ from Hoffmann's branch indices.

8. Hoffmann, *Wachstum*, p. 389.

9. Yamane, Taro, *Statistics. An Introductory Analysis*, New York 1964, pp. 304-312.

10. Hoffmann, *Wachstum*, p. 453.

11. Hoffmann, *Wachstum*, p. 331-334.

For each year from 1851 to 1913 I have then aggregated the growth factors of each of the nine branches to produce a growth factor for the whole economy according to the following formula:

$$\frac{I_t^{(1)}}{I_{t-1}^{(1)}} \cdot VS_{t-1}^{(1)} + \frac{I_t^{(2)}}{I_{t-1}^{(2)}} \cdot VS_{t-1}^{(2)} + \dots + \frac{I_t^{(9)}}{I_{t-1}^{(9)}} \cdot VS_{t-1}^{(9)} = GF_t$$

I = index value of production in branches 1 to 9, as given by Hoffmann

VS = share of total value-added of each branch 1 to 9

GF = growth factor of the whole economy

The annual growth factors thus calculated are presented in Table 2. Annual growth rates in percent result when the data are transformed into $(GF-1) \cdot 100$.

Technically the growth factors could also easily be transformed into an index for the period 1850–1913 similar to Hoffmann's (1913 = 100). This would, however, not result in an index in the conventional sense because it would not be based on a constant weighting structure as required for indices of prices or production. In a strict sense, only each growth factor in itself constitutes an index of production for the current year in relation to the preceding year (= 1). A time series of index values cumulated from the annual growth factors would be a concatenation of the series of annual indices. Such an index of production does not allow the quantification of average annual growth rates over a very long period, such as from 1850–1913, because the weighting structures at the beginning of the series are too different from those at the end. But Hoffmann's index of production is also a doubtful basis for calculating the average annual growth rate over the 63 years before the First World War; it is true that it is computed with a constant weighting structure (1913), but the weighting shares lose in validity the further away in time from the base year they are applied to the aggregation of the branch indices to the index for overall production activity.

The growth rates, however, given in Table 2, should indicate annual growth of Germany's net domestic product more reliably than those derived from the Hoffmann index precisely because the weights are adjusted annually to the current branch structure of value-added. Since this structure did not change dramatically over a period of, say, one decade, in contrast to the longer period from 1850 to 1913, it is justified to calculate from Table 2 average annual growth factors—the geometric mean of the growth factors—over a period of ten years or so. The differences between the average annual growth rates during such periods derived from the data in Table 2, on the one hand, and from Hoffmann's index, on the other, are shown in Table 3.

The divergences tend to diminish in the course of the period from 1850 to 1913. This is what had to be expected since the current weighting structures tend to approach the one used by Hoffmann (1913 value-added structure). The differences are greatest during the so-called take-off period of Germany's industrialization up to 1874.¹²

12. Rostow, Walt W., *The Stages of Economic Growth. A Non-Communist Manifesto*, Cambridge 1960, p. 38. Rostow, Walt W., *The World Economy. History and Prospect*, Austin, Tex.-London 1978, p. 401.

Hoffmann, Walther G., *The Take-off in Germany*, in: Rostow, Walt W. (ed.), *The Economics of Take-off into Sustained Growth*, London 1963, pp. 93–118.

Table 1: Value-added in Current Prices in the Nine Branches of the German Economy 1850-1913 in Million Marks

1	2	3	4	5	6	7	8	9
Agriculture; Forestry, Fisheries	Mining, Salt Works	Industry, Crafts	Transport	Commerce, Banking, In- surance, Cata- strophe Trade	Domestic Service	Other Services without Mili- tary Services	Military Services	Non-agricul- tural Housing
1850	1,753	76.2	89.7	271.5	293	458	53	223
1851	2,050	83.2	102.4	285.5	307	469	54	229
1852	2,480	86.2	112.2	299.2	335	470	55	245
1853	2,560	98.2	120.0	324.1	366	471	55	258
1854	3,101	122.5	141.0	356.8	417	475	56	261
1855	2,774	135.4	158.2	374.6	451	476	57	266
1856	3,373	143.7	165.3	376.9	444	481	58	268
1857	3,071	156.1	188.9	370.3	396	497	58	273
1858	2,707	157.7	194.8	364.4	384	510	60	280
1859	2,782	142.4	185.2	368.1	381	524	62	286
1860	3,382	136.8	210.0	388.4	404	531	73	293
1861	3,305	135.8	220.7	407.5	429	535	77	299
1862	3,485	148.0	248.5	414.4	432	539	74	308
1863	3,622	162.2	233.5	420.4	423	548	71	327
1864	3,579	177.2	236.9	423.0	415	553	73	350
1865	3,371	191.1	313.9	429.9	421	559	73	370
1866	3,551	195.6	330.5	451.4	437	599	93	390
1867	3,821	208.8	320.4	486.7	491	639	88	409
1868	4,545	219.9	358.8	529.5	521	681	89	430
1869	3,980	228.3	384.0	550.7	504	691	90	443
1870	3,833	231.3	414.4	594.2	518	703	115	454
1871	4,142	282.9	431.6	638.0	541	713	230	462
1872	4,722	358.6	511.4	716.7	571	772	122	479
1873	5,022	403.4	558.1	791.0	617	834	129	510
1874	5,487	483.2	606.1	840.4	654	897	125	562
1875	4,865	352.8	644.0	830.9	609	1,000	139	622
1876	5,129	316.9	646.9	823.9	601	1,101	130	666
1877	5,323	274.8	660.5	822.3	612	1,111	133	698
1878	5,102	277.8	669.2	857.9	619	1,121	136	730
1879	4,706	262.8	674.0	878.4	628	1,143	136	757
1880	5,116	290.4	729.7	900.9	633	1,148	137	774
1881	5,117	300.5	767.7	927.2	617	1,176	144	790
1882	4,899	337.7	824.0	964.4	636	1,196	145	808
1883	5,263	345.9	869.2	999.5	655	1,223	145	830
1884	5,275	349.4	872.8	1,014.7	636	1,240	148	855

1885	5,116	354.0	4,839.0	879.3	1,047.9	644	1,257	151	882
1886	5,070	356.0	5,136.5	894.2	1,070.5	635	1,285	155	862
1887	5,260	364.4	5,493.1	954.7	1,119.5	641	1,344	166	936
1888	5,867	386.4	6,055.3	1,036.5	1,189.4	656	1,409	170	973
1889	5,426	446.9	6,618.2	1,092.5	1,251.9	673	1,470	173	1,015
1890	6,124	531.5	7,034.4	1,123.0	1,334.1	686	1,539	180	1,068
1891	5,741	548.1	7,046.7	1,144.2	1,401.2	708	1,599	187	1,122
1892	6,181	530.8	6,997.5	1,155.4	1,445.7	720	1,654	192	1,176
1893	6,033	513.0	6,990.1	1,212.7	1,484.9	723	1,717	205	1,225
1894	5,970	520.9	7,057.7	1,248.7	1,527.4	726	1,758	215	1,270
1895	5,837	525.3	7,333.1	1,286.5	1,606.6	746	1,806	219	1,311
1896	5,959	581.0	8,009.5	1,342.1	1,710.5	765	1,851	222	1,354
1897	6,669	654.9	8,649.5	1,451.1	1,804.5	769	1,900	225	1,398
1898	7,353	726.4	9,359.8	1,573.0	1,921.8	775	1,952	206	1,447
1899	6,892	835.6	10,291.3	1,685.5	2,040.0	780	2,009	214	1,514
1900	6,939	968.7	11,110.8	1,826.6	2,193.4	781	2,110	227	1,581
1901	6,817	971.5	10,608.3	1,788.0	2,253.2	778	2,219	233	1,658
1902	7,361	916.4	10,532.5	1,822.6	2,336.1	779	2,249	233	1,731
1903	7,515	962.4	11,143.9	1,959.1	2,503.7	810	2,339	238	1,810
1904	7,788	1,023.3	11,810.4	1,986.1	2,671.2	842	2,426	257	1,889
1905	8,585	1,079.2	12,644.6	2,140.7	2,836.1	883	2,507	294	1,964
1906	8,754	1,217.6	13,966.9	2,332.8	3,068.6	933	2,612	352	2,051
1907	8,859	1,396.6	15,001.7	2,496.8	3,257.7	966	2,856	361	2,145
1908	9,145	1,433.3	14,413.4	2,337.0	3,330.2	974	2,970	303	2,241
1909	9,594	1,392.1	14,515.8	2,460.1	3,455.2	985	3,077	315	2,314
1910	10,070	1,446.2	15,513.4	2,610.5	3,625.4	992	3,372	314	2,416
1911	10,285	1,519.1	16,607.1	2,679.7	3,827.9	1,023	3,682	306	2,508
1912	11,144	1,694.6	17,900.8	2,998.9	4,096.6	1,072	3,857	335	2,605
1913	11,270	1,882.2	18,561.3	3,146.0	4,296.5	1,061	4,000	346	2,687

Source: Hoffmann, *Wachstum*

- (1) Value-added (Table 65, Column 9).
- (2) Labor income (Table 120, Column 2) + capital income*.
- (3) Labor income (Table 120, Column 3) + capital income*.
- (4) Value-added as computed from value-added in 1913 prices (Table 91, Column 9) multiplied by the price index of transport services (Table 148, Column 9).
- (5) Labor income (Table 120, Column 5) + capital income*.
- (6) Labor income (Table 120, Column 6).
- (7) Labor income (Table 120, Column 7).
- (8) Labor income (Table 120, Column 8).
- (9) Capital income (Table 122, Column 8).

* Hoffmann gives capital income in branches 2, 3 and 5 only in summary form. For my calculations I divided the sum roughly as follows: 7% branch 2, 8% branch 3 and 6% branch 5. This portion falls to branch 3 and, furthermore, since capital income in these three branches is of minor value compared to labor income, it should be of insignificant importance that possible shifts in the current share of capital income were not taken into account.

*Table 2: Annual Growth Factors of Germany's Net Domestic Product at Factor Cost 1851-1913**

1851	0.9980	1872	1.0765	1893	1.0495
1852	1.0192	1873	1.0373	1894	1.0263
1853	0.9956	1874	1.0813	1895	1.0500
1854	1.0219	1875	1.0064	1896	1.0351
1855	0.9905	1876	0.9963	1897	1.0377
1856	1.0873	1877	0.9928	1898	1.0404
1857	1.0565	1878	1.0485	1899	1.0371
1858	0.9960	1879	0.9794	1900	1.0459
1859	1.0023	1880	0.9935	1901	0.9785
1860	1.0632	1881	1.0255	1902	1.0227
1861	0.9872	1882	1.0168	1903	1.0581
1862	1.0483	1883	1.0534	1904	1.0415
1863	1.0797	1884	1.0271	1905	1.0238
1864	1.0356	1885	1.0235	1906	1.0314
1865	1.0105	1886	1.0071	1907	1.0468
1866	1.0137	1887	1.0434	1908	1.0146
1867	1.0013	1888	1.0432	1909	1.0211
1868	1.0644	1889	1.0333	1910	1.0390
1869	1.0067	1890	1.0343	1911	1.0359
1870	1.0033	1891	1.0006	1912	1.0413
1871	1.0377	1892	1.0399	1913	1.0461

* Each in constant prices of the previous period using current value-added shares as weights.

*Table 3: Comparison of Average Annual Growth Rates for Different Periods between 1850 and 1913**

	according to Hoffmann, Table 101	Net Domestic Product according to Table 2	Difference	Population (Hoffmann, Table 1)
	%	%	%	%
1850-1857	2.13	2.36	0.23	0.48
1857-1863	2.56	2.88	0.32	1.00
1863-1874	2.94	3.31	0.37	0.73
1874-1883	1.14	1.22	0.08	1.02
1883-1890	2.81	3.02	0.21	0.97
1890-1900	3.46	3.62	0.16	1.30
1900-1907	2.71	2.87	0.16	1.46
1907-1913	3.26	3.29	0.03	1.29

* The periods correspond roughly to business cycles.

The annual average growth rates derived from Table 2 exceed those derived from Hoffmann's index by .2 and .3 percentage points during the years up to 1863, and by even .4 percentage points in the period 1863–1874. These differences are substantial, for they correct Hoffmann's annual average growth rates by between 11 and 13 percent upwards. The cumulation effect of such an increase in the growth rates for almost a quarter of a century is great and important for the assessment of Germany's economic growth in this early period of industrialization. Its relative impact is even more striking when annual growth is expressed in per capita terms, the rates of which roughly result when subtracting the growth rates of population (also in Table 3) from those of the net domestic product.

The differences between annual average growth rates of net domestic product calculated in the two ways narrow in the years 1874 to 1907 to a margin of .1 to .2 percentage points. The margin practically disappears for the above mentioned reason during the last period from 1907 to 1913.

It is, however, noteworthy that for all periods observed Hoffmann's growth rates are lower than those derived from Table 2. The differences of up to .4 percentage points indicate the magnitude, in which the growth rates of the German economy determined by Hoffmann, especially during the third quarter of the 19th century, are biased by his weighting method, namely by the use of constant value-added shares (1913) over the whole period back to 1850.

Zusammenfassung:

Das Wachstum des Nettoinlandsprodukts in Deutschland, 1850–1913

Walther G. Hoffmanns Daten zum Wachstum der deutschen Wirtschaft seit 1850 sind bisher in vielfältiger Weise von Wachstumstheoretikern und Wirtschaftshistorikern zur Überprüfung von Wachstumstheorien und wirtschaftshistorischen Interpretationen des Industrialisierungsprozesses in Deutschland herangezogen worden. Die Daten selbst, ihre Quellen, ihre Zusammenstellung und die dabei benutzten Annahmen und Schätzverfahren haben bisher jedoch noch keine umfassende kritische Bearbeitung erfahren. In diesem Beitrag wird die Methode, die Hoffmann für die Aggregation der Produktionsindizes von neun Sektoren der Wirtschaft zu einer Zeitreihe für das Wachstum des realen Nettoinlandsprodukts zu Faktorkosten in Deutschland 1850–1913 verwendet hat, kritisch vorgestellt. Sodann wird der Hoffmannschen Zeitreihe eine nach einem anderen Verfahren geschätzte gegenübergestellt, um die Größenordnung festzustellen, in der die Wachstumsrate des realen Nettoinlandsprodukts zu Faktorkosten in Deutschland in jener Periode von jeweils gewählten statistischen Verfahren der Indexberechnung abhängt. Während Hoffmann die Struktur der Wertschöpfung seiner neun Wirtschaftssektoren aus dem Jahr 1913 als konstante Gewichtung für die Aggregation der Sektorindizes zum Index für die Produktion der Gesamtwirtschaft in Deutschland benutzt, verwendet der Autor in seinem Berechnungsverfahren eine jährlich über die Gesamtperiode 1850–1913 angepaßte Wertschöpfungsstruktur für die Gewichtung der Wachstumsraten in den einzelnen Sektoren zwecks Aggregation zur jährlichen Wachstumsrate der Gesamtwirtschaft.

Im Ergebnis liegen die vom Autor berechneten Wachstumsraten des deutschen Nettoinlandsprodukt höher als die von Hoffmann ermittelten. Die Unterschiede nehmen bis 1913 jedoch tendenziell ab, da sich die Gewichtungstrukturen beider Verfahren im Zeitablauf einander annähern. Die Unterschiede sind für die Periode des sog. take-off der deutschen Industrialisierung bis 1874 am größten und machen in dieser Periode im mehrjährigen Durchschnitt bis zu 0,4 Prozentpunkte aus. Dadurch werden die Hoffmannschen jährlichen Wachstumsraten um bis zu 13% nach oben korrigiert.